Applied Research

Design of Experiment - Tire Aging

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Presentation Topics

- Introduction
- Project Design
- Issues
- Discussion

Introduction

Statistics on Tires in the Field

- **Number of tires on the road in America in 1999 - non-commercial vehicles (cars, LT, SUVs, etc.)**
  - **822 million**
- **Number of tires shipped in 2001:**
  - **300 million (822,000/day)**
- **Average use 2001:**
  - **43,000 miles / 3.6 years**
    - **Note: Large distributions in average use**

Data Source: Rubber Manufacturer's Association - www.rma.org

Primary Objective

- **NHTSA wants reasonable assurance that all tires covered by the FMVSS 139 will wear out (have less than 3/32nds tread left) before they suffer a safety related failure:**
  - **Tread Separation**
  - **Sidewall Failure (Blowout)**
  - **Bead Failure**

Tire Aging Test Background

- The agency reserved the right to revise tests or incorporate additional tests in the proposed FMVSS 139
- The agency has identified the need to test tires that have been subjected to the equivalent of many years of use
- Currently, there exist no industry accepted accelerated tire aging method

Background (continued)

- Applied Research was given until April, 2004 (15 months from now) to recommend an aged tire endurance test
- There is not enough time to complete a multi-parameter tire aging test development program
- Applied Research will evaluate known methods and target a single set of test parameters for the new oven/mechanical test

Project Design

Tire Aging Project Basics

Quantify How Tires Age in the Field

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Evaluate Proposed Tire Aging Methods

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Develop an Aged Tire Endurance Test

Tentative Tire Aging Project Schedule

Meet with Industry / Project Planning	10/02 - 1/03
Tire Collection in Arizona	2/03 - 3/03
Analysis & Testing of Field Tires	3/03 - 10/03
Evaluation of Tire Aging Methods	3/03 - 10/03
Aged Tire Endurance Test Development	10/03 - 3/04

Tire Collection from the Field

- **Proposed collection area: Phoenix, Arizona**
  - Average annual temperature 72.9°F (22.7°C)
  - The State of Arizona had the highest per capita Firestone tire tread separation rate in the U.S.
  - Population: 1,210,420 (7th largest U.S. city – large pool of vehicles)

Tire Collection – 8 Different Categories

- **Original Equipment**
  - P-metric tires
    - Compact car
    - Mid-size car
    - Mid-size SUV
    - Large SUV
- **Replacement Brand**
  - P-metric tires
    - Mid-size car
    - Full-size car
    - Large SUV
  - Light Truck
    - Load Range E

Tire Selection Requirements

- **Production availability**
  - In production 1998 to current
- **Popularity**
  - OE: Must have been OE on at least one US vehicle
  - Replacement: Must be available at a large tire retailer
- **Design legacy**
  - No ‘major’ design changes from 1998 – current
- **Alternate tire recommendations must be of same size and application**

Collection Strategy

- Send out letters in advance of tire teams with instructions and details on the tires we plan to collect
- Allow the stores to contact customers with these tires and offer them a new set of tires for free
- Make only as many service appointments as is necessary for each model

Tires Collected from the Field

- **Field Collection**
  - Collect 720 tires off of Phoenix area vehicles
    - 60 of each tire (12 different models)
    - 20 in each age group 1: 97-98, 2: 99-00, 3: 01-03
  - Assume 192 / 720 tires fail inspection (repairs, abuse…)
  - Laboratory Analysis – 144 tires*
  - FMVSS 139 Endurance Test – 144 tires*
  - Remainder of the tires used for tire aging test development
  - Data to be released after analysis by NHTSA

*(48 of each age / 4 each model)

OE Tire Collection List

Type	Use	Size	Load Index	Speed Rating	Brand	Model	OE Brand	OE Vehicle
P-metric	Compact car	P185/65R14	85	H	Hankook	H406	Daewoo Hyundai Kia	Nubira Accent Sephia II
P-metric	Mid-size car	P195/65R15	89	S	BFGoodrich	Touring T/A	Chevy	Cavalier
P-metric	Mid-size car	P205/65R15	92	V	Goodyear	Eagle GA	Lexus	ES300
P-metric	Mid-size SUV	P235/75R15	108	S	Michelin	LTX M/S	Ford Dodge	E 150 Van Ram Van 1500
P-metric	Large SUV	P265/75R16	114	S	Firestone	Wilderness AT	Chevy GMC	Silverado/Tahoe Sierra/Yukon
Metric	SUV	255/55R18	109	H	Goodyear	Wrangler HP	Land Rover	Range Rover 4.6 HSE / Discovery

Replacement Tire Collection List

Type	Use	Size	Load Index	Speed Rating	Brand	Model
P-metric	Mid-size car	P205/60R15	90	H	Kumho	ECSTA HP4
P-metric	Mid-size car	P205/65R15	92	S	Continental	Touring Contact A/S
P-metric	Full-size car	P205/70R15	95	S	Yokohama	Avid Touring
Metric	SUV	255/65R16	109	H	General	Grabber ST A/S
P-metric	Full-size car	P235/45R17	94	V	Pirelli	P6 FourSeason
LT	Full-size LT	LT245/75R16/E	120	Q	Pathfinder	ATR A/S OWL

Phase I Test Tires

Type	Size	Load Index	Speed Rating	Brand	Model
P-metric	P195/65R15	89	S	BFGoodrich	Touring T/A
P-metric	P205/65R15	92	V	Goodyear	Eagle GA
P-metric	P235/75R15	**108***	S	Michelin	LTX M/S
Metric	255/65R16	109	H	General	Grabber ST A/S
P-metric	P265/75R16	114	S	Firestone	Wilderness AT
LT	LT245/75R16/E	**120****	Q	Pathfinder	ATR A/S OWL

***Extra Load / **Load Range E**

- **12 Tire Models Collected From The Field (Phoenix)**
- **6 Tire Models Will Be Tested In Phase I**

Laboratory Analysis

Test	Replicates per Tire	Skim Rubber	Belt Edge Rubber	Tread	Sidewalls	Bead Area
Peel strength skim & wedge: Radial peel SS and radial peel OSS	2	*	*			
Total crosslink density	5	*	*	*	*	*
Fixed oxygen by weight	3	*	*	*		
Tensile test						
Strain ratio	5	*	*			
Elongation at break (ultimate)	5	*	*			
100% modulus (room temp)	5	*	*			
Extension ratio at break	5	*	*			
Tensile strength	5	*	*			
Shore hardness	5		*	*		
Micro hardness	5	*				

Test	Replicates per Tire	Skim Rubber	Belt Edge Rubber	Tread	Sidewalls	Bead Area	Shoulder Radial Scan	Bead Radial Scan
Crosslink density distribution	3	*	*	*	*	*		
Indentation modulus	1						*	*